



**CENTER FOR EDUCATION +  
RESEARCH IN CONSTRUCTION**

DEPARTMENT OF CONSTRUCTION MANAGEMENT

# RECORD MODELING INDUSTRY PRACTICES

Technical Report

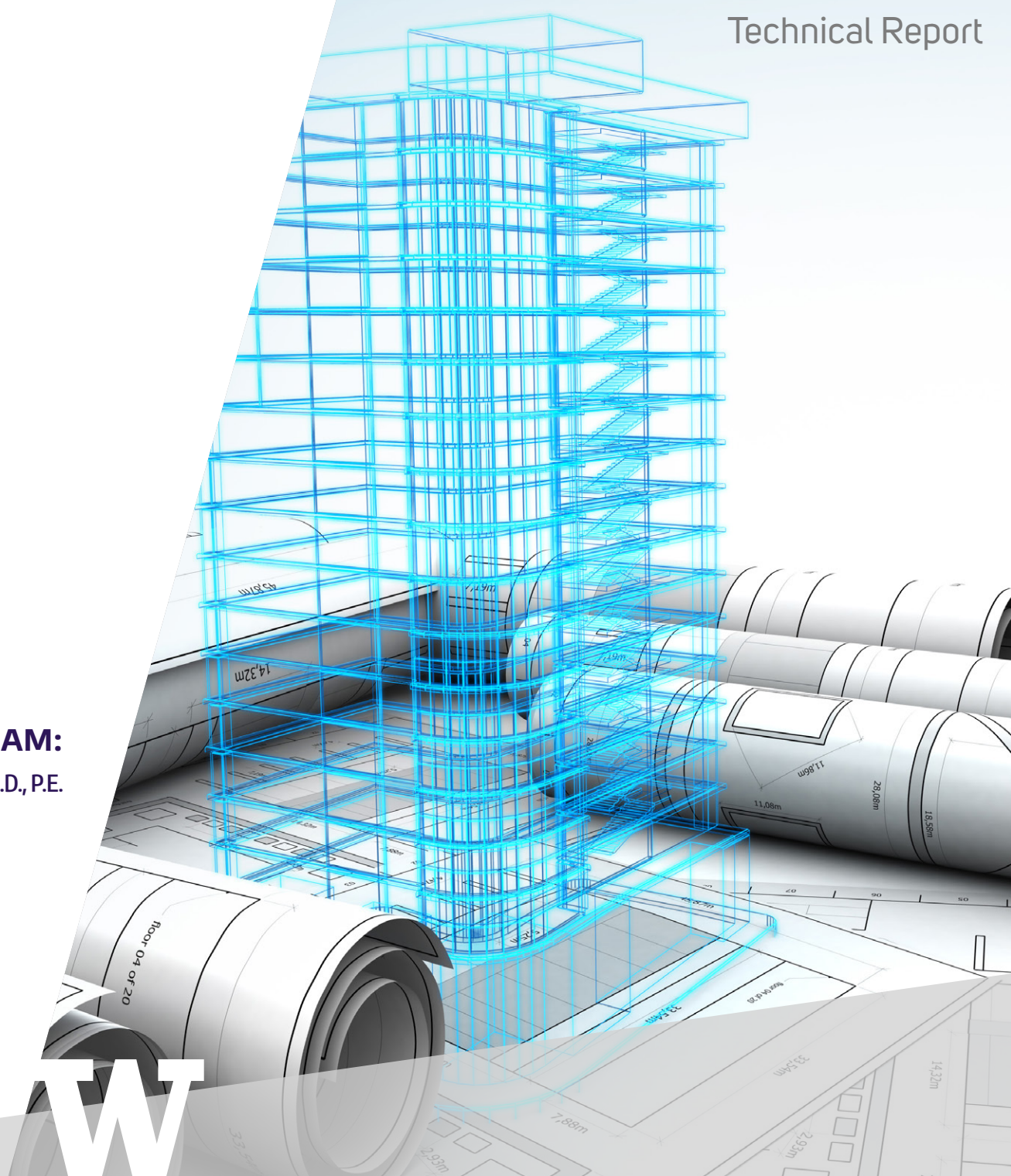
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## ABOUT CERC

The Center for Education and Research in Construction (CERC) is a locus of research, scholarship and discovery in the UW's Department of Construction Management and allied disciplines of architecture, engineering and real estate. Focused on the people and practices of a dynamic, innovative construction industry, CERC develops new concepts and innovative solutions as well as improved methodologies for design, construction and operations. With active labs focused on Safety and Health, Project Delivery and Management, Virtual Design and Construction, Infrastructure Development, and Sustainable Built Environments the CERC faculty are not only experts and researchers in a wide array of topics but also lead the field in translating that expertise into excellent construction education practices and pedagogy to train tomorrow's construction professionals.

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## EXECUTIVE SUMMARY

This technical report presents a review of current Record Modeling practices in the building sector of the construction industry. Our Center for Education and Research in Construction (CERC) research team collected and reviewed Record Modeling specifications from large public and private institutional owners from across the U.S.. These specification documents consisted of published Building Information Modeling (BIM) guidelines, contract specifications, and BIM Project Execution Planning documents. During this document review, the CERC team found two types of models used in Record Modeling Specifications: 1) Design-Intent Record Models and 2) As-built Construction Record Models.

These two types of Record Models are connected to different designer and contractor roles and responsibilities in Record Model delivery. They also have different Levels of Development (LOD), meaning they have different levels of information complexity and different capacities in how they can be used in operations and maintenance. Design-Intent Record Models are typically the responsibility of the designer and typically have a lower LOD (e.g., LOD 300). These models contain information about the main systems of a facility, are cost effective to create, and easy to update throughout a facility's lifecycle. Design-Intent Record Models can also be used for commissioning, making it easy for the owner to update and track commissioning data. Alternatively, As-built Construction Record Models are typically the responsibility of the contractor, and tend to have a higher LOD (e.g., LOD 500). These more detailed models can include high fidelity information, such as fabrication documents, and reflect information from all building systems (e.g., architectural, civil, structural, mechanical, life safety, electrical systems). While they provide highly detailed building information, they can also be more complicated to use.

The following summary is the first comprehensive review of Record Modeling processes and specifications. This review intends to help owners to determine their Record Modeling requirements based on their operations and maintenance needs and the needs of project teams.

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# 1 INTRODUCTION

In many regions of the United States, Building Information Modeling (BIM) has become commonplace, while in other regions the construction industry is still in earlier phases of adoption. While designers and contractors use BIM for collaboration, decision-making, and archiving information on design intent, materials, and systems, many owners are developing record model specifications that formally request contractors and/or designers to deliver models during turnover of a capital project. A key, emerging role for BIM is the production of a Record Model for operations and maintenance. Since approximately 60 to 70 percent of facility ownership costs occur during operations and maintenance,<sup>1</sup> facility management—and the efficient and effective use of BIM data—plays a crucial role in helping owners with cost savings. Furthermore, large institutional owners operate and maintain multiple, complex facilities that have special operational and maintenance needs. While owners begin to leverage BIM for facilities management, design and construction teams must be prepared to understand these owner needs and expectations when producing Record Models. If this is achieved, then designers and contractors can provide owners with Record Models that contain complete, accurate, and actionable data on their assets to support efficient operations and add financial value for the owner.

When producing a Record Model, designers and contractors should use a combination of different building models, such as design, construction, and shop/fabrication models. Record Models should be an accurate representation of the physical conditions, environment, and assets of a facility such that it is a reliable information resource for operations. Record Models allow operators to understand building systems that are often hidden behind walls as well as find asset locations and manage spaces. At a minimum, Record Models should include component information related to the main architectural, structural, and MEP elements.<sup>2</sup> An owner may also require that a Record Model include equipment and information for space planning systems.<sup>3</sup> (*continued*)

1. Michael P. Gallaher et al., *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry*.

2. John Messner et al., *BIM Planning Guide for Facility Owners*.

3. Ibid

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In practice, building teams create Record Models as as-built records of the construction. During facility turnover, the designer or contractor transfers the Record Model to the owner. The owner can link the Record Model to their Computerized Maintenance Management System (CMMS), or to any other documents needed for facility management. The owner or facility manager can then continue to update the model throughout the lifecycle of the facility and use it for operations and maintenance.

While the primary function of a Record Model is facility management, Record Models also aid in permitting processes, future modeling and design coordination for renovations, and minimizing building turnover information and disputes. Record Models also provide an owner with an accurate model of the building, equipment, and its spaces, creating potential synergies with other BIM uses. In this sense, a Record Model, which is the culmination of all models created during the project, can better accommodate owner needs and has the ability to embed future databases.<sup>4</sup>

This technical report summarizes current Record Modeling practices in the building sector of the construction industry. The CERC team collected Record Modeling specifications from large private and public owners in the form of published Building Information Modeling (BIM) guidelines, contract specifications, and BIM Project Execution Planning documents. In this review, the CERC team found two main types of models used in Record Modeling Specifications: 1) Design-Intent Record Models and 2) As-built Construction Record Models. These two types of Record Models are connected to different designer and contractor roles and responsibilities in Record Model delivery. They also have different Levels of Development (LOD), meaning they have different levels of information complexity and different capacities in how facilities can use them in operations and maintenance. Typically, the construction team delivers As-built Construction Record Models, which have a higher LOD, and the design team delivers Design-Intent Record Models, which have a lower LOD. *(continued)*

4. Penn State Computer Integrated Construction, "Record Modeling."

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While an owner receives multiple models produced during the design and construction phases, these models will not benefit the owner's long term costs unless they can be used in a facility's operations and maintenance. There has been an increasing interest in Record Modeling in recent years as more and more owners require teams use BIM in their projects so that they can use these models and their data after project turnover for facility management. As there has not been a comprehensive review of practices for Record Modeling in the building industry so far, this review is intended to help owners understand current Record Modeling practices and determine which record modeling process and specifications will meet the needs of their organizations and project teams.

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## 2 DIFFERENCES BETWEEN RECORD MODEL TYPES

### Design-Intent Record Models

Design-Intent Record Models are lower fidelity, thus cost effective models that contain a design LOD of the main systems in a facility. Consequently, Design-Intent Record Models tend to be easier to update throughout the lifecycle of the facility, often making them a preferred model for facilities. These models typically have a lower LOD, often at 300. In contrast, As-built Construction Models are often at LOD 500.

Many university organizations use Design-Intent Record Models.<sup>5</sup> For example, Pennsylvania State University's BIM Guide<sup>6</sup> states that these types of models are a more cost-effective solution for facility management purposes as they can be created with a single software package, making the model easy to use and modify throughout a facility's lifecycle. Owners can also use Design-Intent Record Models for commissioning. For example, the Massachusetts Port Authority<sup>7</sup> uses a Design-Intent Record Model to map and track recently updated commissioning data. Among the organizations requiring a Design-Intent Record Model, most request an additional As-built Construction Model for archival and as-built documentation purposes.<sup>8</sup> *(continued)*

5. For examples, see Messner et al., *BIM Planning Guide for Facility Owners*; FIU, *Building Information Modeling (BIM) Standard & Guide*; Ron Dellaria et al., *Building Information Modeling (BIM) Project Delivery Standards*; VCU, *Building Information Modeling (BIM) Guidelines and Standards for Architects, Engineers, and Contractors*; USC, *USC's Project Revit Record Requirement Execution Plan (PRxP):Template*; Princeton University, *Princeton University BIM Specification*.

6. Messner et al., *BIM Planning Guide for Facility Owners*.

7. MPA, *BIM Guideline for Vertical and Horizontal Construction*.

8. For examples, see SI, *SI BIM Standards*; Messner et al., *BIM Planning Guide For Facility Owners*; Dellaria et al., *Building Information Modeling (BIM) Project Delivery Standards*; USC, *USC's Project Revit Record Requirement*.



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Many owners choose to require both types of Record Models. In these cases, the designer is typically responsible for the Design-Intent Record Model and the contractor is responsible for an additional As-built Construction Model. These responsibilities are usually defined during BIM Execution Planning. In the case of Princeton University,<sup>9</sup> the designer is responsible for making necessary model revisions to issue bulletins, answer RFIs, and issue 2D drawings in connection with design intent or clarifications during construction. The contractor is also required to update the As-built Construction Model and meet with the owner periodically to validate these changes.<sup>10</sup> In the case of the Massachusetts Port Authority,<sup>11</sup> the Designer and Contractor BIM Managers facilitate model handover between design and construction teams to ensure ongoing coordination between all models in the project.

*Execution Plan (PRxP): Template*; Princeton University, *Princeton University BIM Specification*; VA, *VA BIM Manual V2.0*; MPA, *BIM Guideline for Vertical and Horizontal Construction*; ASBO, *BIM Resource Guide*.

9. Princeton University, *Princeton University BIM Specification*.

10. Ibid.

11. MPA, *BIM Guideline for Vertical and Horizontal Construction*.

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## Summary Table: Design-Intent Record Models

Institute	LOD	LOD Standard Reference	File Type	Process
Pennsylvania State University	Owner Specifies	-	Native & IFC	Penn State OPP requires that the design team provide a Design Intent Record Model for facility management & the construction team provides an As-Built Construction Model.
Florida International University	300 Record Model, 500 As-Built Construction Model	BIMForum's 2013 Draft LOD	Native & IFC	The designer delivers the Design Intent Record Model and the contractor delivers the As-built Construction Model.
The Ohio State University	300 Record Model, 400 for As-built Construction Model	OSU BIM Project Delivery Standard based on BIMForum's 2015 Draft LOD	Native & IFC	Requires the designers to provide an As-Built Design Intent Record Model, or "As-Maintained BIM," with LOD of 300. Requires the contractor to provide an As-Built Construction BIM, or "Archived BIM," with LOD 400. COBie is also required.
Virginia Commonwealth University	Per LOD Matrix (300)	VCU LOD Matrix	Native	Requires a Design Intent Record Model with LOD of 300. The Designer and Contractor identify the deliverables of the team and milestones in BEP.
University of Southern California	-	-	Native	The design team produces the Design Intent Record Model and the construction team completes and delivers the As-built Construction Model to the owner. .COBie is also required.
Princeton University	-	Model Level of Development Matrix	Native	The designer delivers the Design Intent Record Model and the contractor delivers the As-built Construction Model.
Department of Veteran Affairs	-	VA Object Element Matrix	-	The designer provides a Design Intent Record model, called the "As-Built FM Model." The contractor provides the As-Built Construction Model.
Smithsonian Institute	350 (suggested)	Level of Development Matrix and Specific per project requirements	Native & IFC	Smithsonian Institute requires a Design Intent Record Model and an As-Built Construction Model. The BEP should be updated for each project to include the specific scope, parties responsible, guidelines and modeling requirements.
Massachusetts Port Authority	Record Model (300), As-built (350)	AIA/AGC Level of Development - 2014	Native & (IFC Optional)	Requires a Design-Intent Record Model and an As-built Construction Model for each project. Either the design team or construction team may take on responsibility for finalizing Record Model delivery to the MPA, who reviews the models for data and model requirements and integrates the models into the facility management system.
Association of School Business Officials	-	AIA E202	Discusses Native & IFC	Recommends requiring a Record Model containing design intent information with as-built conditions. Suggests that the fabrication details in an As-built Construction Model is more information than the institute needs for facility management.

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## As-Built Construction Record Models

While having a Design-Intent Record Model provides owners with a less complex, easy to use model, some organizations prefer to have only one as-built model to keep and update during the lifecycle of the infrastructure. Some facility owners have determined that their operations staff require high fidelity information such as fabrication documents,<sup>12</sup> leading to a need for a more complex and detailed Record Model. As a result, these organizations and institutions require a single As-built Construction Record Model.

As compared to the Design-Intent Record Model, the As-built Construction Record Models typically provide greater LOD. In the case of NASA,<sup>13</sup> the As-built Construction Record Model reflects the as-built conditions for all building systems (e.g., architectural, civil, structural, mechanical, life safety, electrical systems) with LOD of 500. The model also allows for export into the organization's CMMS and is consistent with the COBie2 Model View Definition, published by the National Institute of Building Science in the Whole Building Design Guide.

Roles and responsibilities around the As-Built Construction Record Models are often determined early in the process. For example, at George Washington University,<sup>14</sup> the contractor and designer determine how they should work together to facilitate information exchange for a single model during the preparation of the BIM Execution Plan. In this example, the architect and contractor document how they will identify changes in the model and what methods they will use to document these changes.<sup>8</sup>

In most cases, the contractor is often responsible for continuously updating the As-built Construction Model throughout the construction process. For example, at NASA, the contractor must include all changes reflected in addenda, approved change orders, field orders, clarifications, RFI responses, and as-built conditions in the As-built Construction Record Model.<sup>15</sup> NASA's contractors also submit the final versions of all Contractor and subcontractor fabrication and detailing models.

12. NASA, *Building Information Modeling Scope of Services and Requirements for Construction Contractor in a Design-Bid-Build Process*.

13. Ibid.

14. GWU, *FIM Procedures Manual*.

15. NASA, *Building Information Modeling Scope of Services and Requirements for Construction Contractor in a Design-Bid-Build Process*.

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## Summary Table: As-Built Construction Record Models

Institute	LOD	LOD Standard Reference	File Type	Process
NASA	500	AIA Document E202 – 2008	Native & IFC	NASA requires the Contractor to provide the As-Built Construction Record Model. The Contractor continuously updates the Record Model throughout the construction process, reflecting all design and construction changes. The Record BIM must map the CMMS and BAS input fields to allow data export from the Record BIM into CMMS and BAS software.
George Washington University	Project Specific, Min 400 for the main elements per LOD Matrix	AIA Exhibit G202-2013	Native	Contractor maintains project as-builts in the BIM model concurrently with the construction process. Designer verifies monthly the Contractor's maintenance of the As-Built Record Model. Owner verifies the model. Designer and Contractor are performing monthly audits of As-Built Record Model.
University of South Florida	LOD 500 in nature with LOD 350 being the base	USF-BIM-EP	Native	The contractor maintains the current condition information with color-coded drawing mark-ups during construction. The designer and/or the owner representatives conduct monthly inspections. The designer is responsible for the final preparations and delivery of the As-built Construction Record Model based on the mark-ups. COBie is also required.
Western Michigan University	500	AIA document E202 – 2008	Native	The Contractor is responsible for the As-Built Construction Record Model.
Los Angeles World Airports	500	Described in the LAWA BIM Requirement document per AIA standards	Native	The Design/Builder continuously updates the model to include RFI's, Change Orders, Submittals, and all other changes affecting the project's design and construction.
Naval Facilities Engineering Command	-	eOMSI Facility Data Workbook	Native	The Contractor modifies the Record Model, which incorporates the real world implementation of the Design Model, including Model Elements and Element Data. The data are refined per the Record Model (As-Built) section of the Model & Facility Data Matrix tab in the eOMSI Facility Data Workbook.
Cleveland Clinic	LOD Matrix provided in BEP	-	Native	The Contractor submits the Record Model/As-Built Model.
US General Service Administration	-	-	Native & IFC	GSA requires a Record BIM for archival purposes, and an As-Built BIM that is editable for capturing building and component updates through the life cycle. COBie is also required.

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## 3 CONCLUSION

When reviewing Record Modeling practices in the industry, we find that most organizations require a Design-Intent Record Model and an As-built Construction Model. The benefits of the Design-Intent Record Model is that it is simpler to update throughout the lifecycle of the facility. Owners may choose to keep the Design-Intent Record Model active, while putting the As-Built Construction Model in an archive. However, As-built Construction Models have a greater depth of LOD with all changes archived that some owners find invaluable even as the facility changes during routine maintenance and operations.

Whether designers and contractors should provide owners with a Design-Intent Record Model depends upon the needs of the owner. For owners requiring simpler models that are easy to modify and change in the day to day operations of the facilities, a Design-Intent Record Model will suit those needs. For facilities staff who prefer greater depth in informational details, including fabrication documentation, an As-built Construction Record Model is the only model needed, alleviating the need for duplicated modeling efforts.

Regardless of the deliverable path selected, determining and clarifying the roles and responsibilities of owners, contractors, designers, and subcontractors is imperative. Owners need to clarify with team members what information to provide for the model deliverables, the standards for providing that information in a way that is a meaningful for the owner, and how to best coordinate between different project stakeholders to exchange this information and keep the model updated throughout the construction process. This collection of references will provide examples and guidance from owners who have developed Record Modeling specifications and practices.

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## 4 REFERENCES

ASBO (Association of School Business Officials). *BIM Resource Guide: A Guide for Implementing Building Information Modeling in State of Maryland and Washington DC Public School Construction Projects*. Annapolis: Association of School Business Officials, 2013. Accessed May 24, 2017. [http://asbo.org/images/downloads/Resources/bim\\_resource\\_guide.pdf](http://asbo.org/images/downloads/Resources/bim_resource_guide.pdf).

Dellaria, Ron, Brian Skripac, and Andy Burg. *Building Information Modeling (BIM): Project Delivery Standards*. Version 2.0. Columbus: The Ohio State University, 2016. Accessed May 24, 2017. [https://fod.osu.edu/sites/default/files/ohio-state\\_bim\\_pds.pdf](https://fod.osu.edu/sites/default/files/ohio-state_bim_pds.pdf).

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Messner, John, Chimay Anumba, Robert Leicht, Ralph Kreider, Eric Nulton, Ashwin Ramesh, Dan Weiger, and Kim Price. *BIM Planning Guide for Facility Owners*. Version 2.0. University Park: The Pennsylvania State University, 2013. Accessed May 24, 2017. [http://bim.psu.edu/resources/owner/bim\\_planning\\_guide\\_for\\_facility\\_owners-version\\_2.0.pdf](http://bim.psu.edu/resources/owner/bim_planning_guide_for_facility_owners-version_2.0.pdf).

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VCU (Virginia Commonwealth University). *Building Information Modeling (BIM) Guidelines and Standards for Architects, Engineers, and Contractors*. Richmond: Virginia Commonwealth University, 2013. Accessed May 24, 2017. <http://www.fmd.vcu.edu/docs/VCU%20BIM%20Guidelines%20-%2002072014.pdf>.

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## 5 ONLINE RESOURCES

### Design Intent Record Models Bim Guides

Design-Intent Record Models are cost-effective models that contain the design level information of main systems, but lack fabrication details. The following list of BIM Guides provide details on specific institution's Record Model specifications, processes, and team roles and responsibilities.

**Pennsylvania State University**

BIM Planning Guide For Facility Owners Version 2.0 (2013)

**Princeton University**

Princeton University BIM Specification (2012)

**Florida International University**

Building Information Modeling (BIM) Standard & Guide (2014)

**Virginia Commonwealth University**

Building Information Modeling (BIM) Guidelines and Standards for Architects, Engineers, and Contractors (2013)

**Massachusetts Port Authority**

BIM Guideline For Vertical & Horizontal Construction (2015)

**U.S. Department of Veteran Affairs**

VA BIM Manual V2.0 (2016)

**Association of School Business Officials**

BIM Resource Guide (2013)

**Smithsonian Institute**

SI BIM Standards (2015)

**University of Southern California**

Appendix: USC's Project Revit Record Requirement Execution Plan (PRxP) Template (2015)

**The Ohio State University**

Building Information Modeling (BIM) Project Delivery Standards (The Ohio State University) (2016)

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## As-Built Construction Record Model Bim Guides

As-Built Construction Record Models benefit organizations that want to have comprehensive building information and only one as-built model to keep and update during the lifecycle of the infrastructure. The following list of BIM Guides provide details on their specific institution's Record Model specifications, processes, and team roles and responsibilities.

### **National Aeronautics and Space Administration**

Building Information Modeling Scope of Services and Requirements for DesignBuild (2010)

Building Information Modeling Scope of Services and Requirements for Construction Contractor in a Design-Bid-Build Process (2011)

### **The George Washington University**

FIM Procedures Manual (2014)

### **University of South Florida**

USF BIM Guidelines and Standards: For architects, engineers and contractors (2015)

### **Los Angeles World Airports**

Project Requirement, PR – 20 Virtual Design & Construction (VDC), Building Information Model (BIM) (2014)

### **U.S. General Services Administration, Public Building Service (GSA)**

GSA BIM Guide for Facility Management (2011)

### **Western Michigan University**

BIM Project Execution And Standards Guide For Western Michigan University Facility Management (2013)

### **Cleveland Clinic**

Cleveland Clinic BIM Implementation Plan (2013)



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